recommended change.

Drawings

The examiner objected to the drawings and recommended three changes. In FIG. 5 the examiner indicated that reference label -48a- needs to be provided. In the specification, the reference to 48a has been deleted to that all of the conductive strips are referenced as 48. A copy of FIG. 5 is attached having a red-lined correction with a new reference number 48.

The examiner also objected to FIG. 8 and 14 and the examiner's recommended changes have been included in the attached red-lined copies of these figures.

Formal drawings incorporating these changes will be provided upon approval of the examiner.

Claims

The examiner rejected claims 1-3 and 7 under 35 U.S.C. 112, second paragraph, as being indefinite, and these claims have been amended to make them more definite.

The examiner objected to claims 1 and 6, both of which have been amended to address the examiner's concerns.

35 U.S.C. 102(b)

The examiner rejected claims 1-7 as being anticipated by Kim et al A Rectangular TEM Waveguide With Photonic Crystal Walls for Exitation of Quasi Optic Amplifiers, (1999) IEEE MTT-S Digest, pages 543-545, which discusses photonic crystal substrates that are used to produce a TEM mode in a rectangular waveguide. One substrate includes hexagonal pads arranged in a honeycomb lattice and connected to a ground plane by substrate vias. The article

also discusses a striped photonic crystal showing a similar behavior to the hexagonal structure with the additional property that it is also possible to use the crystal on top and bottom walls of a waveguide.

Applicants' invention is different and focuses on use of a high impedance wall structure, where the impedance is variable. This allows a waveguide utilizing the wall structure to vary the structure's impedance to shift the phase of the signal being transmitted by the waveguide. Kim et al. does not disclose teach or suggest using a photonic crystal structure with variable impedance/properties to shift the phase of the waveguide's transmitted signal.

To emphasize this difference, claim 1 has been amended to include the limitations that each of said wall structures presents a surface impedance to transmitted signals of the waveguide, with the impedance being alterable. Each of the wall structures presents a high impedance to a resonant frequency signal transmitted by said waveguide, the altering of the surface impedance causing the phase of said resonant frequency signal to change. Claims 2-4 have also been amended to add limitations regarding the variable nature of the wall structure's impedance. Kim et al. does not disclose, teach or suggest these limitations.

The examiner also provisionally rejected claims 1-7 under the judicially created doctrine of obviousness double patenting, citing claims 11, 18, 20-22 of copending Application No. 408,992. Applicant respectfully submits that claims 1-7 do not claim the same invention and the claims in Application No. 408,992, in that there are no limitations in the '992 application related to wall structure having an alterable impedance. Applicant

respectfully requests reconsideration of this rejection.

Claims 1-7 as amended do not read on the non-elected species of the invention as outlined in the examiner's past restriction requirement. The non-elected species focus on providing a circuit element to adjust the resonant frequency of a waveguide (FIGs. 4-6), a waveguide having different regions (FIGs. 7-10), and a module of multiple waveguides for phase shifting or beam steering (FIGs. 11-14). The claims as amended focus on having a variable surface impedance in a wall structure to shift the phase of a waveguides transmitted resonant frequency.

Claim 8 is being added to include the limitation that the impedance can be altered to present as primarily an inductive impedance to the resonant frequency. Support for this claim can be found in the specification, claims and drawings as originally filed.

Claims 1-8 are now believed to be in proper form for allowance, and a Notice of Allowance is respectfully requested.

Respectfully submitted,

October 17, 2002

Jaye G. Heybl
Attorney for Applicants
Registration No. 42,661

KOPPEL JACOBS PATRICK & HEYBL
555 St. Charles Drive, Suite #107
Thousand Oaks, CA 91360
(805)373-0060

<u>VERSION WITH MARKINGS TO SHOW CHANGES MADE</u>

Paragraph on page 1, lines 11-26:

Electromagnetic signals are commonly guided from a radiating element to a destination via a coaxial cable, metal waveguide, or microstrip transmission line. As the frequency of the signal increases, these devices must have smaller cross-sections to transmit the signals. For example, a metal waveguide that is 58.420 cm wide and 29.210 high at its inside dimensions, transmits signals in the range of 0.32 to 0.49 GHz. A metal waveguide that is 0.711 cm wide and 0.356 cm high at its inside dimensions, transmits signals in the range of 26.40 to 40.00 GHz. [Dorf, <u>The Electrical Engineering Handbook, Second Edition</u>, Section 37.2, Page 946 (1997)]. As the signal frequencies continue to increase<u>,</u> a point is reached where use of these devices become impractical. They become too small and expensive, require precision machining to produce, and their insertion loss can become too great.

Paragraph on page 2, lines 7-16:

One method of amplifying these high frequency beams is to combine the power output of many small amplifiers in a quasi-optic amplifier array. The amplifiers of the array are oriented in space such that the array can amplify a [Gaussan] <u>Gaussian</u> beam of energy rather than amplifying a signal guided by a transmission line. However, commercial use of these "open" systems is not practical because they are fragile and can be contaminated by the surrounding environment. Also, there is no simple, durable and reliable mechanism for beam phase shifting or steering.

Paragraph on page 3, line 20-33:

A second impedance structure has been developed that

is particularly applicable to the sidewalls and/or top and bottom walls of metal rectangular waveguides. [M. Kim et. al., A Rectangular TEM Waveguide with Photonic Crystal Walls for Excitation of Quasi-Optic Amplifiers, (1999) *IEEE MTT-S*, Archived on CDROM]. Either two or four of the waveguide's walls can have this structure, depending upon the polarizations of the signal being transmitted. The structure comprises parallel conductive strips on a substrate of dielectric material. It also includes conductive vias through the sheet to a conductive layer on the substrate's surface opposite the strips. At the resonant frequency, this structure presents as series of high impedance resonant L-C circuits.

a

Paragraph on page 4, line 24 to page 5, line 1

Waveguides employing these high impedance structures are also able to transmit signals close to the resonant frequency that would otherwise be cut-off because of the waveguide's dimensions if all of the waveguide's walls were conductive. At the resonant frequency, the waveguide essentially has no cut-off frequency and can support uniform density signals when its width is reduced well below the width for which the frequency being transmitted would be cut-off in a metal waveguide.

Paragraph on page 6, lines 4-24:

Another embodiment of the new waveguide includes both a phase shifter and an amplifier array to amplify the phase shifted signal. For a vertically polarized signal, a multi-region impedance structure is initially provided on the waveguide's sidewalls. The first region is a conductive strip impedance structure that is resonant to the beam

frequency at the front of the waveguide. Progressing further down the waveguide, the gap between the conductive strips narrows, reducing the structure's resonant frequency. Next the signal enters the phase shift region where the gap between the strips maintain a constant width. Between the gaps is a varactor structure that varies the capacitance across the gaps in response to voltage changes. As described above, this change in capacitance shifts the beam's phase. The signal then enters the second transition region where the gaps widen so that the structure resonates at the signal frequency. The signal then enters the amplifier region, which has a [having the] strip structure on all four walls that resonates at the signal frequency. This section provides a near uniform signal to the amplifier, and the amplified signal emits from the waveguide.

Paragraph on page 7, lines 5-11:

To reduce beam degradation from reflection off the front edge of the module the waveguides in the module include a front end launching region in the form of a patch impedance structure that is resonant at the beam frequency. This makes the front edges of the waveguides invisible to the entering wavefront, allowing only the TEM mode of the signal to enter the waveguide and preventing signal reflection.

Paragraph on page 8, line 23 to page 9, line 2:

FIG. 1 shows a new phase shifting waveguide 10 constructed in accordance with the present invention, which comprises a top wall 15, a bottom wall 17 and left and right sidewalls 14, 16. It [has] further comprises strip impedance structures 12 on its left and right sidewalls 14,

16. Each impedance structure includes a plurality of conductive strips 18 parallel to the waveguide's longitudinal axis and facing its interior. The strips 18 are made of a conductive material and are provided on a substrate of dielectric material 20. Conductive sheets 24 are provided over the exterior of each dielectric substrate 20 with vias 22 included along each strip's longitudinal axis extending through the substrate to its respective sheet 24 to form a conductive path between the strips and the sheets.

Paragraph on page 10, lines 15-22:

Numerous materials can be used to construct the impedance structure 12. The dielectric substrate 20 can be made of many dielectric materials including, but not limited to, plastics, poly-vinyl carbonate (PVC), ceramics, or high resistance semiconductor material such as Gallium Arsenide (GaAs), all of which are commercially available. Highly conductive material should be used for the conductive [patches] strips 18, conductive layer 24 and vias 22.

Paragraph on page 11, line 28 to page 12, line 6:

A second embodiment of the new waveguide phase shifter 40 according to the present invention is shown in FIG. 4, and comprises a top wall 44, a bottom wall 46 and left and right sidewalls 43,45. It [has] further comprises the previously described impedance strip structures 42 on its sidewalls 43, 45, with the strips 48 parallel to the waveguide's longitudinal axis. In this embodiment, the frequency at which the individual structures resonate can

be varied within a range of resonant frequencies below the frequency of the signal the waveguide 40. Different resonant frequencies for the impedance structures result in different shifts in the phase of the signal passing through the waveguide. The resonant frequency of the impedance structure 42 is varied by varying the capacitance between the strips 48.

Paragraph on page 12, lines 7-30:

FIG. 5 is a detailed sectional view of one of the impedance structures 42. It has alternating conductive strips 48 similar to those described above. They have uniform width and are formed on a dielectric substrate 52, that can be made of the same dielectric materials as the 20 in FIG. 1. Conductive vias 54 extend from the strips, through the substrate 52 to a conductive layer 56 on the substrate's outer surface. Control strips 48a are provided between the conductive strips 48 and have a voltage (V) applied to them that controls the capacitance across the gaps between strips 48 and 48 a. Each control strip 48a has vias 55 extending through the dielectric substrate 52 to the conductive layer 56. Each strip comprises a conductive via cap 65 on top of its vias 55, an insulator strip 66 on top of the via cap 65, and a wider conducting voltage strip 67 on the insulating strip 65. Each gap between strips 48 and 48a have a pair of varactor diodes 58 to vary the capacitance across the gaps. Varactor diodes are junction diodes that are utilized for their voltage dependent capacitance. A conductive N+ layer 60 connects each pair of varactor diodes across each gap. Along the edge of each insulating strip 66, between the voltage strip 67 and the varactor diode below, is a conductive coupling strip 68 that provides a conductive path between the

voltage strip 67 and the varactor diode 58.

Paragraph on page 13, lines 13-23:

In fabricating the diodes 58, N+ layers 60 of a semiconductor material such as GaAs, are etched into mesas before the strips 48 are formed. The layer 60 runs along the gaps between the strips and will be partially below the strips 48 [and 48a] on each side of the gaps. The diodes 58 are then formed on the N+ layer 60, with both the N+ layer 60 and the diodes terminating short of the vias 54 and [55A] 55 and separated therefrom by intervening portions of the dielectric material. When the strips 48, insulating layer 66, coupling strip 68 and voltage strip 67 are formed, they extend over a diode 58 on each lateral side.

Paragraph on page 14, lines 18-29:

The signal entering the waveguide encounters a first transition region 90 which is shown in more detail in FIGs. 9 and 10. This region has strips of conductive material 92 on a dielectric substrate 94. Like the above embodiments, conductive vias 96 run from the strips 92 through the dielectric substrate 94 to a conductive layer 98 as best seen in FIG. 10. The structure is different from the above embodiments because the gaps 99 (see FIG. 9) between the strips are initially at a width that allows the structure to resonate at the frequency of the signal passing through the waveguide. The gaps 99 then narrow moving away from the front of the waveguide, reducing the resonant frequency.

Paragraph on page 14, line 30 to page 15, line 1:

As shown by the graph in FIG. 3, decreasing the impedance structure's resonant frequency places the waveguide in the portion of the curve [52] 32 where

additional changes in the resonant frequency result in larger changes in the beam's propagation constant.

Paragraph on page 15, line 26 to page 16, line 6:

The signal then enters the amplifier region 106. An array amplifier chip 108 is positioned within this section to amplify the signal from the second transition section 104. The amplifier region 106 has impedance structures mounted on all four waveguide walls to support both horizontal and vertical polarizations (cross polarized). A signal reaching the array amplifier chip [106] 108 will have uniform E and H fields, and thus, equally drives each of chip's amplifiers. Array amplifier chips [106] 108 are generally transmission devices rather than reflection devices, with the input signal entering one side and the amplified signal transmitted out the opposite side. This reduces spurious oscillations that can occur because of feedback or reflection of the amplified signal toward the source.

Paragraph on page 16, line 25 to page 17, line 5:

Matching grid polarizers 110 and 112 are mounted on each side of and parallel to the array amplifier chip [106] 108. The polarizers appear transparent to one signal polarization, while reflecting a signal with an orthogonal polarization. For example, the output grid polarizer 112 allows a signal with an output polarization to pass, while reflecting any signal with an input polarization. The input polarizer 110 allows a signal with an input polarization to pass, while reflecting any signal with an output polarization. The distance of the polarizers from the amplifier can be adjusted, allowing the polarizers to function as input and output tuners for the amplifier, with

the polarizers providing the maximum benefit at a specific distance from the amplifier.

Paragraph on page 16, lines 7-14:

Array amplifiers chips also change the polarity of the signal 90° as it passes through as is amplified, further reducing spurious oscillations. However, a portion of the input signal carries through the array amplifier with the original input polarization. In addition, a portion of the output signal [will reflected] reflects back to the waveguide area before the amplifier. Thus, in amplifier section [108] 106 both polarizations will exist.

Paragraph on page 16, lines 15-24:

The strip feature of the wall structures allows the amplifier section [108] 106 to support a signal with both vertical and horizontal polarizations. The wall structure presents a high impedance to the transverse E field of both polarizations, maintaining the E field density across the waveguide for both. The strips allow current to flow down the waveguide in both polarizations, maintaining a uniform H field density across the waveguide for both. Thus, the cross polarized signal will have uniform density across the waveguide.

Paragraph on page 18, line 25 to page 19, line 6:

A portion of the incoming beam can reflect off the front edges of the waveguides [112] 113, degrading the signal. To reduce this reflection, each of the waveguides can be provided with a launching region 120, beginning at the entrance to the waveguide [112] 113 and continuing for a short distance down its length. FIGs. 12 and 13 show the

launcher region 120 in more detail. It is similar to the above described strip impedance structures, but instead of strips which extend for the length of the waveguide, it employs an array of mutually spaced conductive patches 122 on a dielectric substrate. The patches are preferably hexagonal shaped, but can also have other shapes. Vias 123 extend from the center of each patch 122, through the dielectric substrate 124 to a conductive layer 125 on the substrate's opposite side (as best seen in FIG. 13).

Paragraph on page 19, lines 7-19:

The launching regions resonate at the frequency of the beam entering the waveguides in the module. The vias which extend through the substrate present an inductive reactance (L), while the gaps between the patches present an approximately equal capacitive reactance (C) at the waveguides resonant frequency. The launching regions thus present parallel resonant high impedance L-C circuits to the beams E field component. The L-C circuits present an open-circuit to the E-field, allowing it to remain uniform across the waveguide. The low impedance on the top and bottom waveguide walls, which do not have impedance structures, allows current to flow and maintain a uniform H field.

Claims

1. (Amended) A rectangular waveguide for shifting the phase of a signal transmitted through it, comprising:

a waveguide comprising a top wall, a bottom wall and two sidewalls; and

at least one pair of opposing impedance wall structures, with one of said at least on one pair being on said top wall and bottom wall, or said sidewalls, or both, [on said waveguide] each of said wall structures [that establish an] presenting a surface impedance to transmitted signals [at a resonant frequency] of said waveguide, said impedance being alterable [and a higher impedance to signals having a frequency higher than said resonant, said wall structures presenting a primarily capacitive impedance to higher frequencies to shift its phase], each of said wall structures presenting a high impedance to a resonant frequency signal transmitted by said waveguide, the altering of said surface impedance causing the phase of said resonant frequency signal to change.

2. (Amended) The waveguide of claim 1, wherein said wall structures present high impedance resonant L-C circuits to [a] said resonant frequency, [and a primarily capacitive impedance to a signal having a frequency higher than said resonant frequency], said impedance being altered to present a primarily capacitive impedance to said resonant frequency.

3. (Amended) The waveguide of claim 1, wherein said wall structures present a high impedance to a signal at [a] said resonant frequency which has an E field transverse to the waveguide axis and parallel to the wall structures, [and a primarily capacitive impedance to a signal having a frequency higher than said resonant frequency], said impedance being altered to present a primarily capacitive impedance to said resonant frequency which has an E field transverse to the waveguide axis and parallel to the wall structures.

4. (Amended) The waveguide of claim 3, wherein each of said impedance wall structures comprises:

a substrate of dielectric material having two sides;

a conductive layer on one side of said dielectric material;

a plurality of mutually spaced conductive strips on the other side of said dielectric material, said strips separated by gaps and positioned parallel to said waveguide's longitudinal axis; [and]

a plurality of conductive vias extending through said dielectric material between said conductive layer and said conductive strips; and

a means for altering said impedance presented to said transmitted signals of said waveguide.

6. (Amended) The waveguide of claim 5, wherein said conductive strips and dielectric substrate [form] defines a series of L-C circuits to said resonant frequency signal having an E field transverse to said conductive strips.

7. (Amended) The waveguide of claim 4, wherein said conductive strips and said dielectric substrate present a capacitive impedance to [a waveguide signal] said resonant frequency having an E field transverse to said conductive strips.

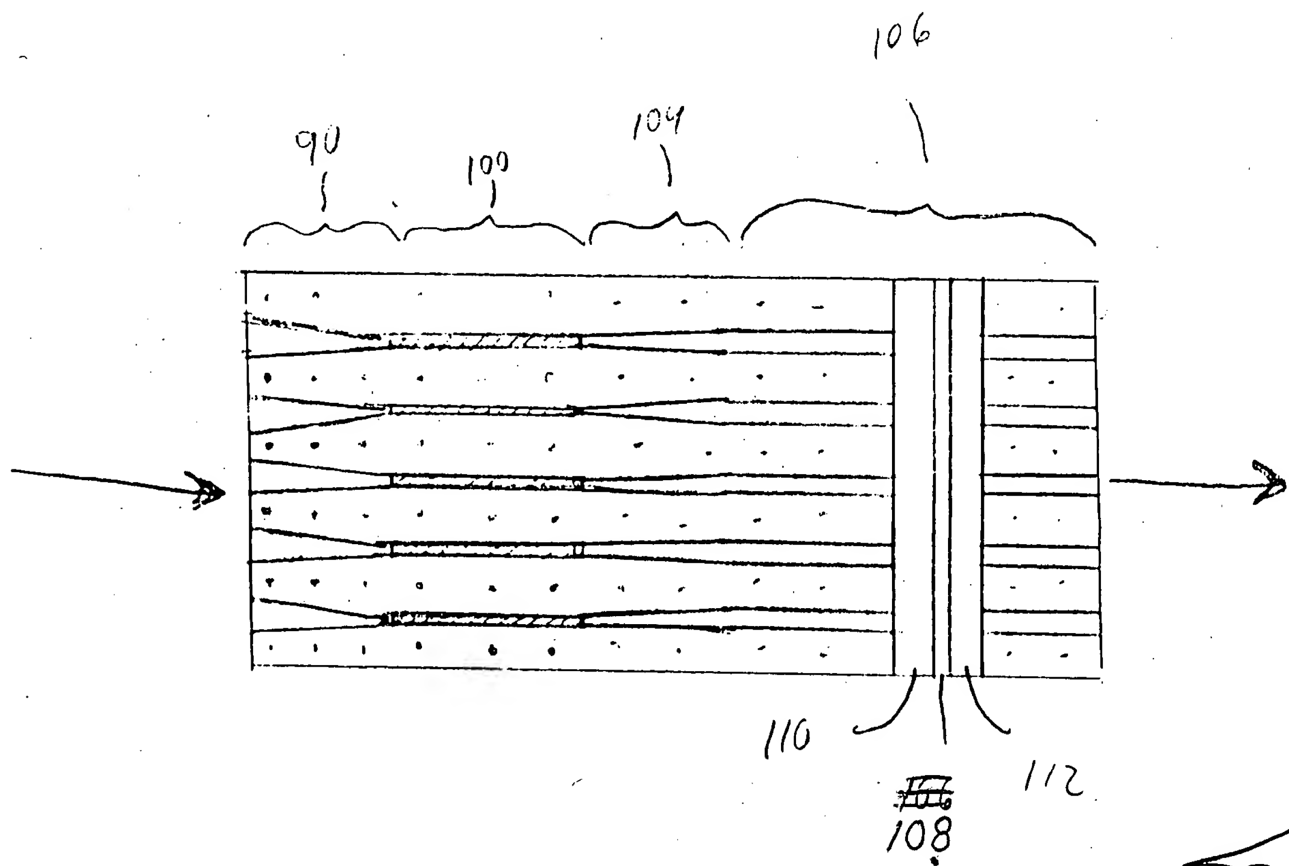

FIG. 8

RECEIVED
OCT 23 2002
TECHNOLOGY CENTER 2800

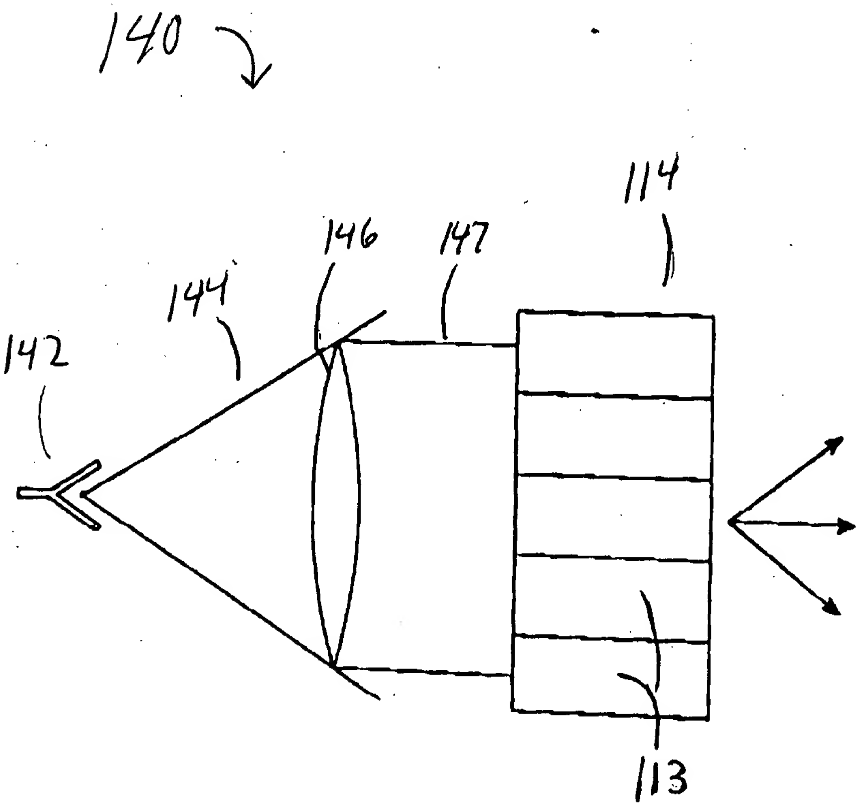

FIG. 14

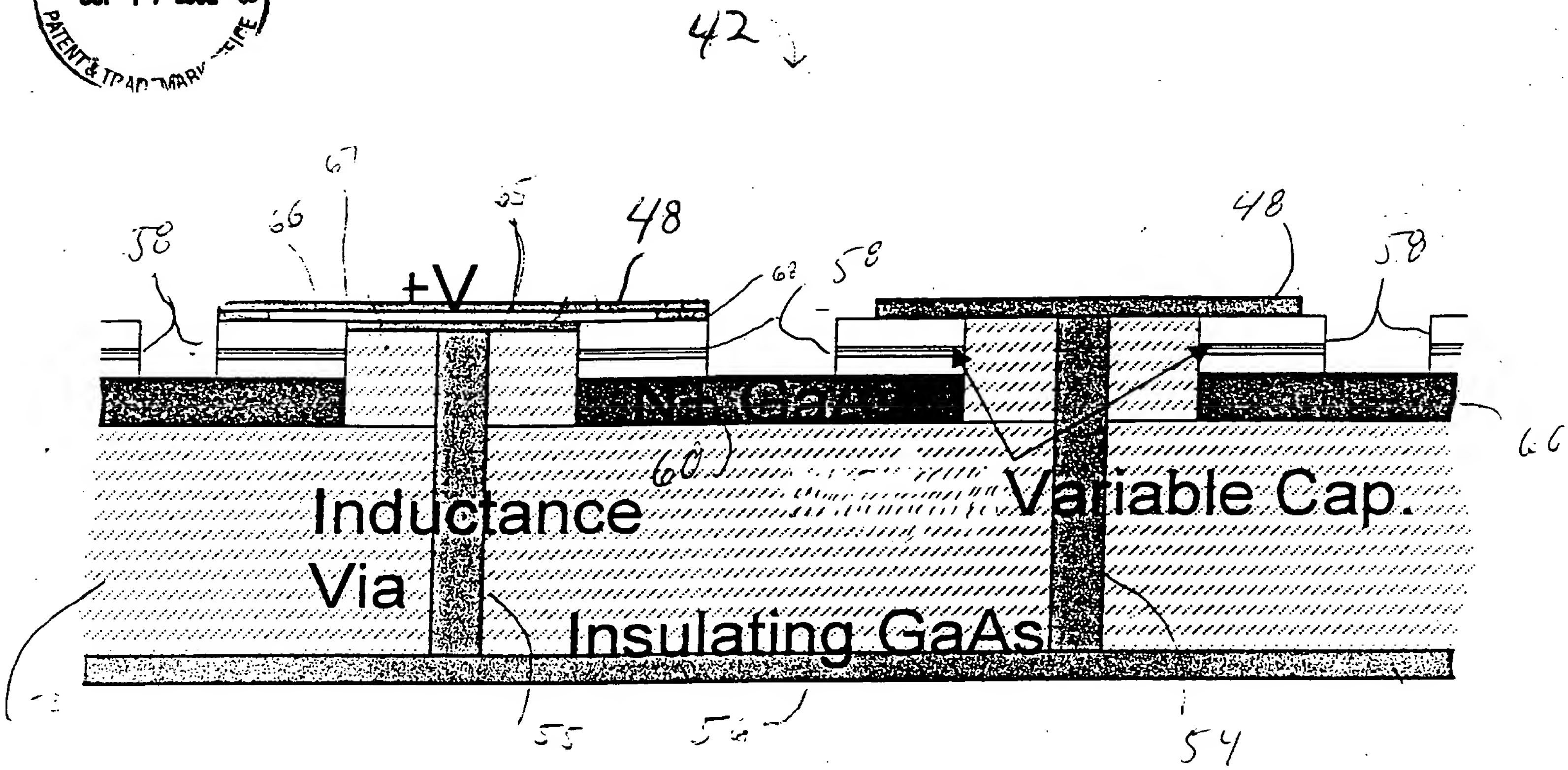
42
58
66
67
65
48
+V
62
58
48
58
N+ GaAs
66
60
Inductance
Via
Variable Cap.
Insulating GaAs
55
54
54

FIG. 5

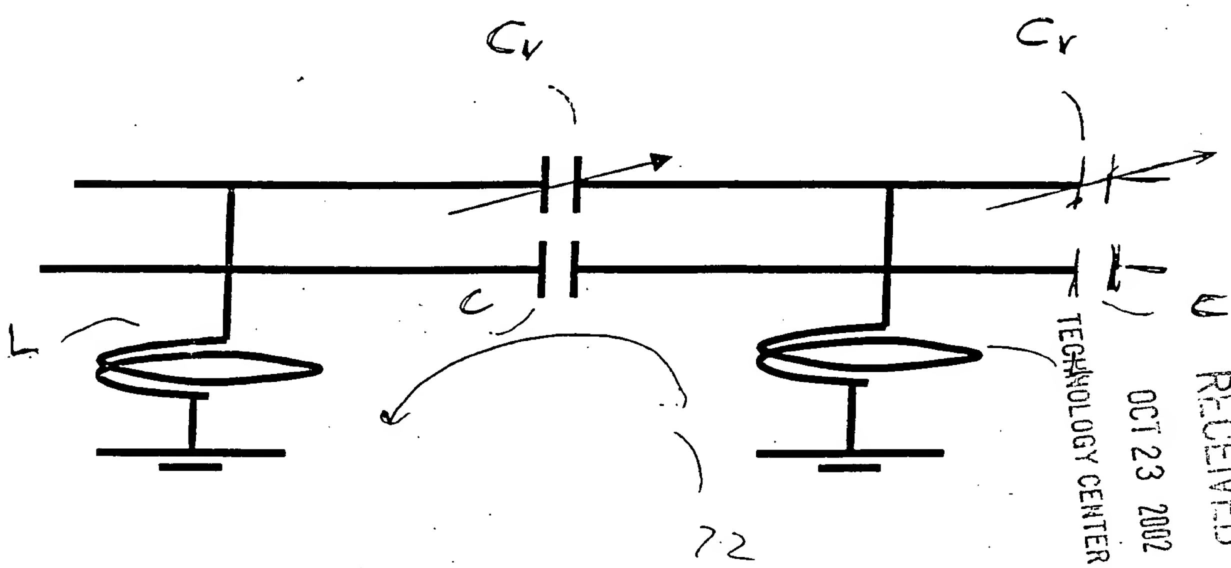
Cv
Cv
C
C
L
72

FIG 6